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An Introduction to MaCOM and its application to operational oceanography

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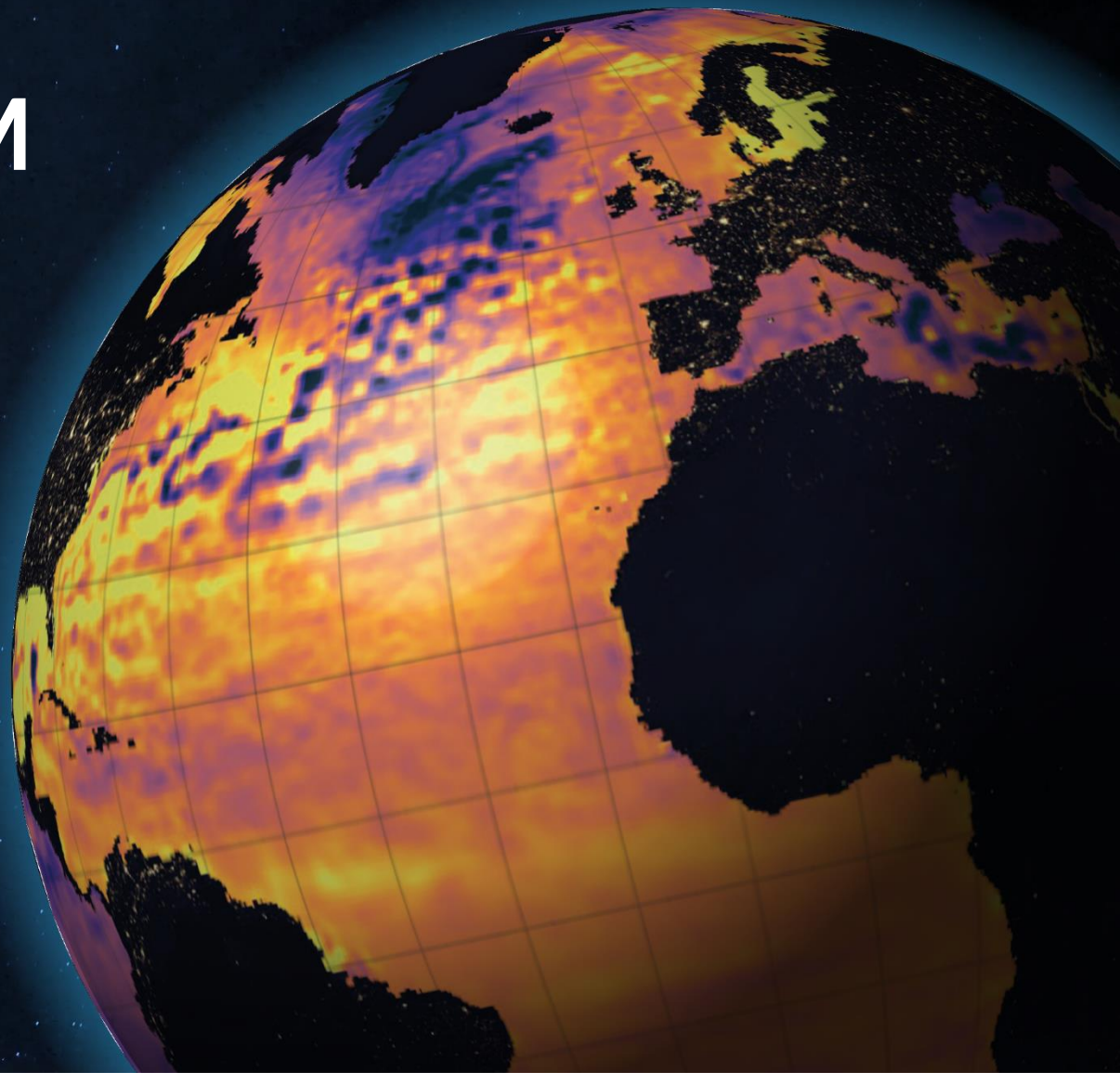

Mass Conservation Ocean Model

妈祖 aCOM

Outline

- Introduction to MaCOM
- Application of MaCOM in operational oceanography
- Conclusion and prospects

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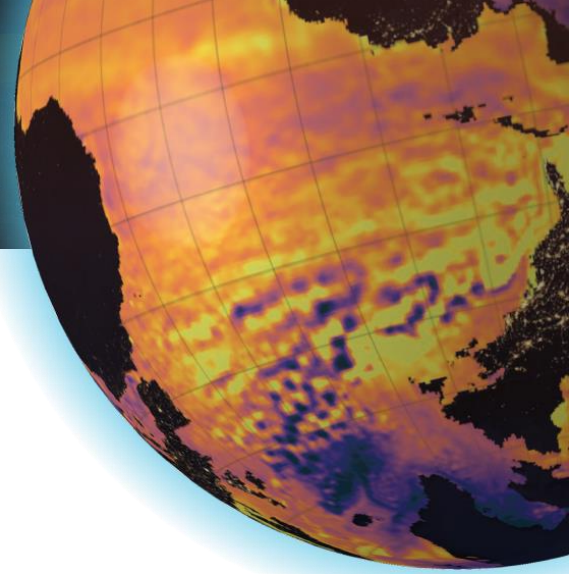


Introduction to MaCOM

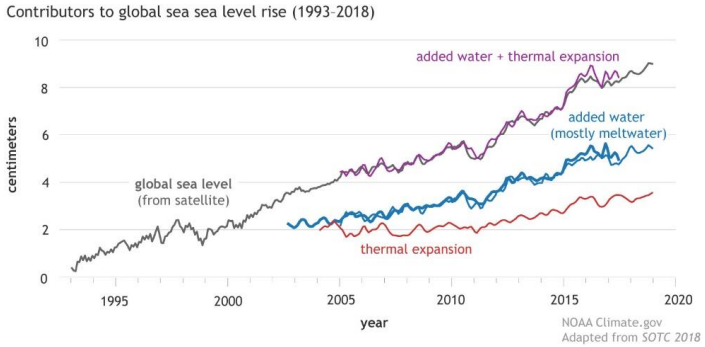
Why we want to develop a new model?

- Most models are complex
- Try some new features
- Easier to maintain operational systems
- Apply some new technologies

Model based on pressure coordinate

1st Advantage

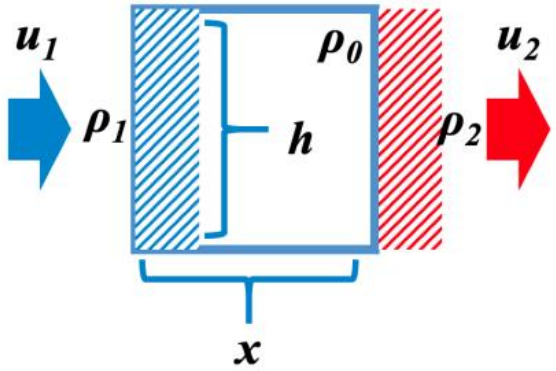
More accurate and direct simulation of sea level changes



2nd Advantage

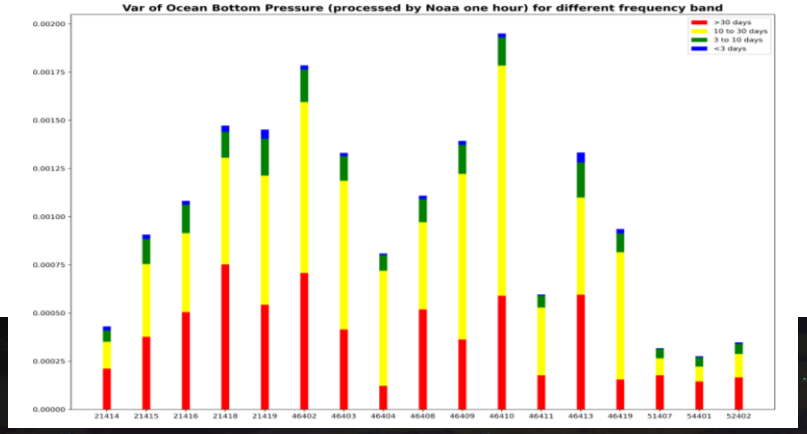
More precise definition of salinity

VCM	kg/m^3	inconsistent with observations
MCM	g/kg	consistent with observations



3rd Advantage

Seafloor pressure observations can be directly assimilated



$$\rho_1 \frac{P}{\rho_1 g} u_1 \delta t = \rho_2 \frac{P}{\rho_2 g} u_2 \delta t \Rightarrow \nabla_P \cdot (u) = 0$$

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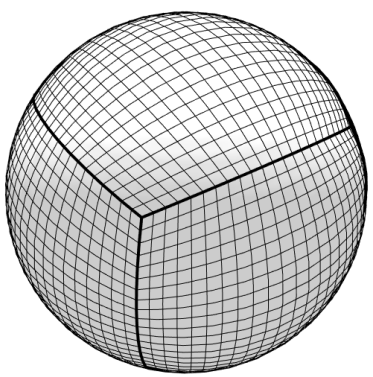
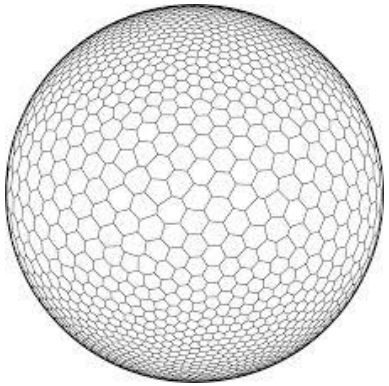
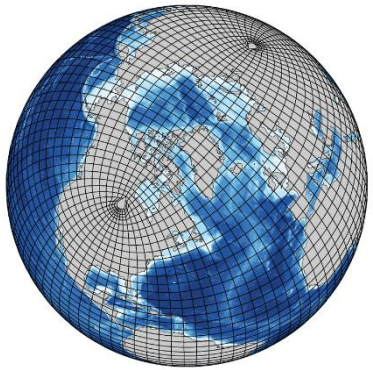
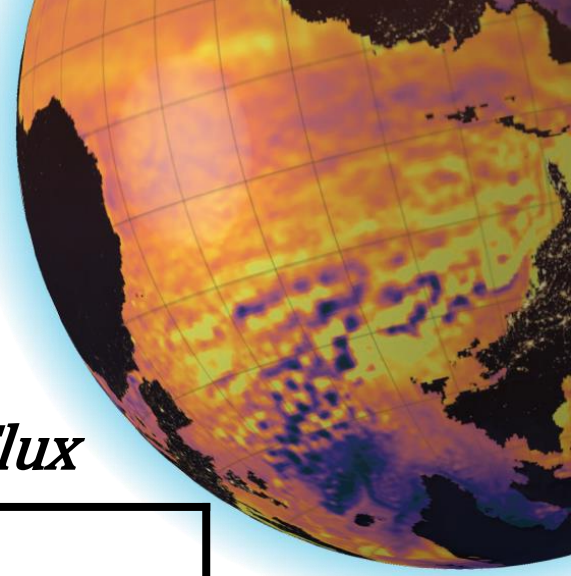
Flexible grid support



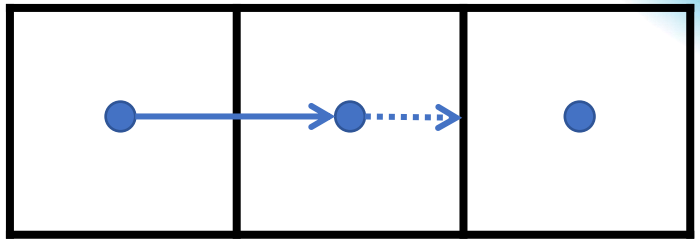


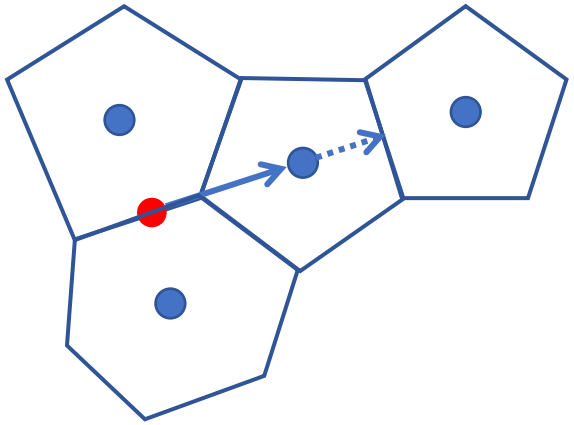




- One model for multiple application scenarios
- Flexible parallel computing
- GPU friendly due to land removed from memory

Adv Flux





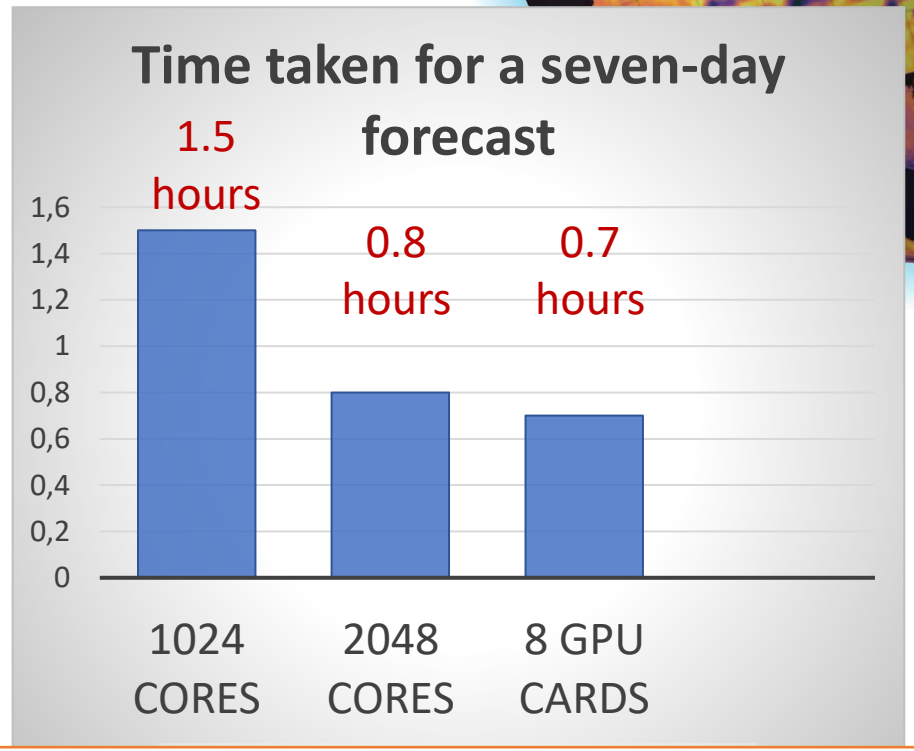
The algorithm under structured mesh can remain unchanged in unstructured mesh

CPU-GPU Heterogeneous computing

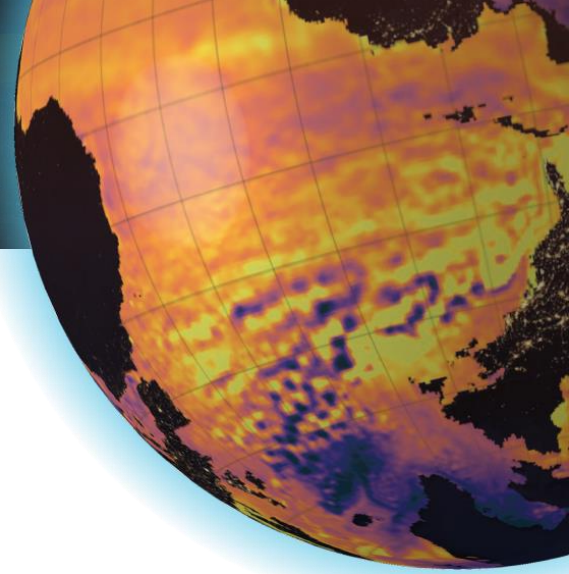
The global ten-kilometer (1/12°) ocean circulation numerical forecast can use a single 8-card GPU server to replace the traditional 40-60 CPU computing nodes (2048 cores)

✓Equipment purchase cost reduced by 2/3

✓Computing energy consumption reduced by 90%



NVIDIA A100 GPU Server vs Intel Xeon Compute Cluster

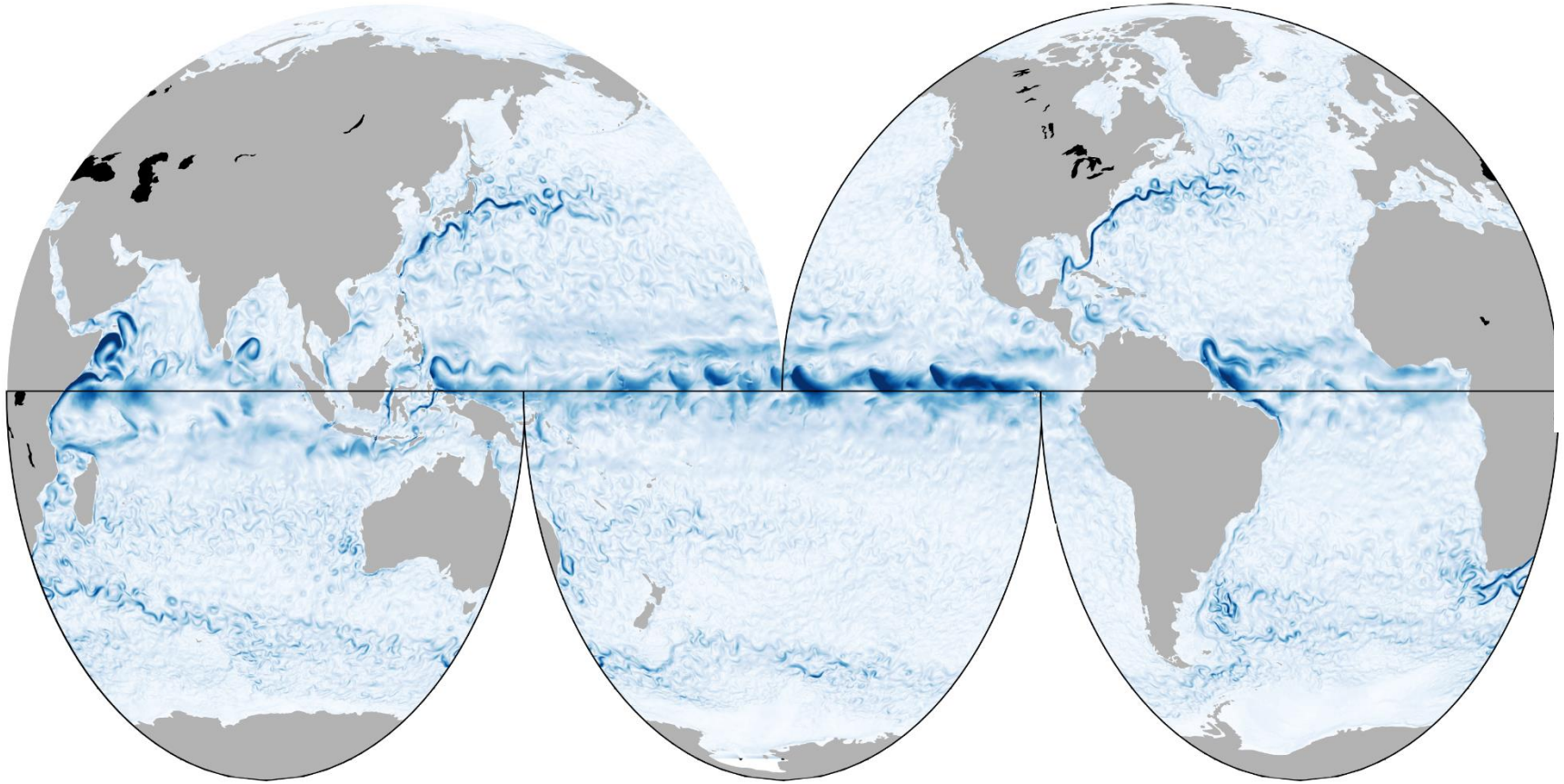


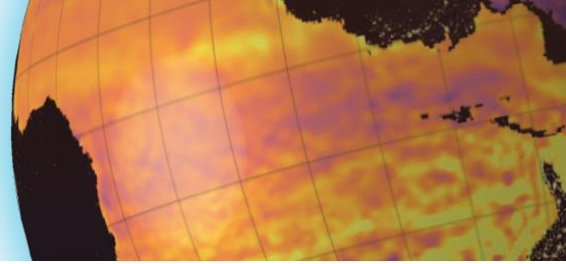
Application of MaCOM

From Global to Coastal

- Global 1/12° forecasting system (CGOFS)
- Western Pacific forecasting system
- Ultra-high resolution marine services (Asia Game Sailing Regatta 2022)

Application of MaCOM in Global ocean forecasting



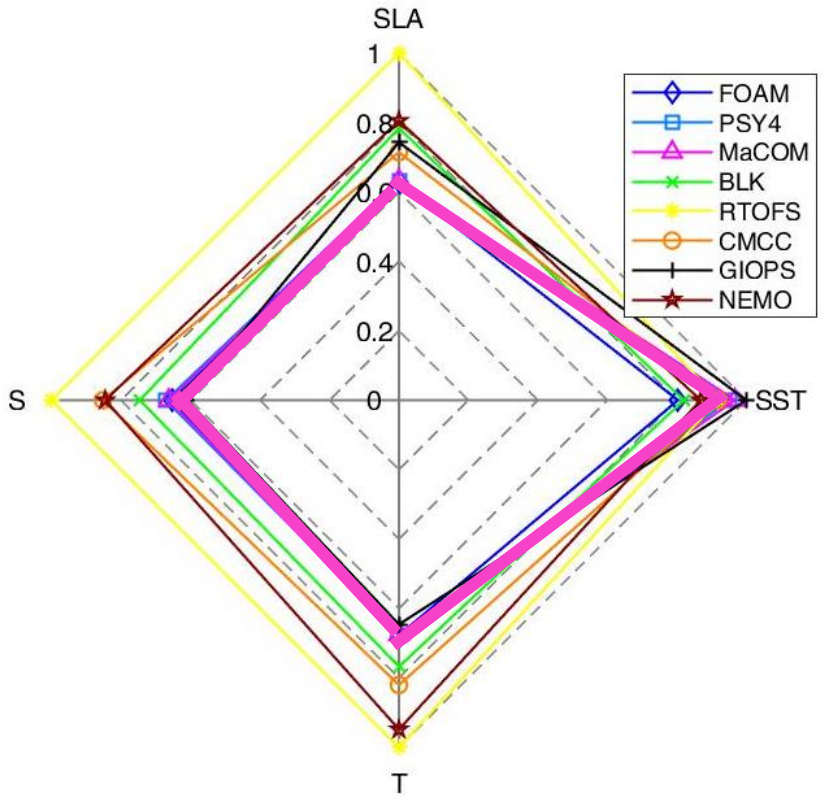


Global application technology

- Cubic Sphere or Tripolar
- Supports up to 1/24° horizontal resolution
- MCM or VCM
- Tidal potential M2, S2, N2, K1, O1, P1, Q1, K2
- Sea ice

Operational configure

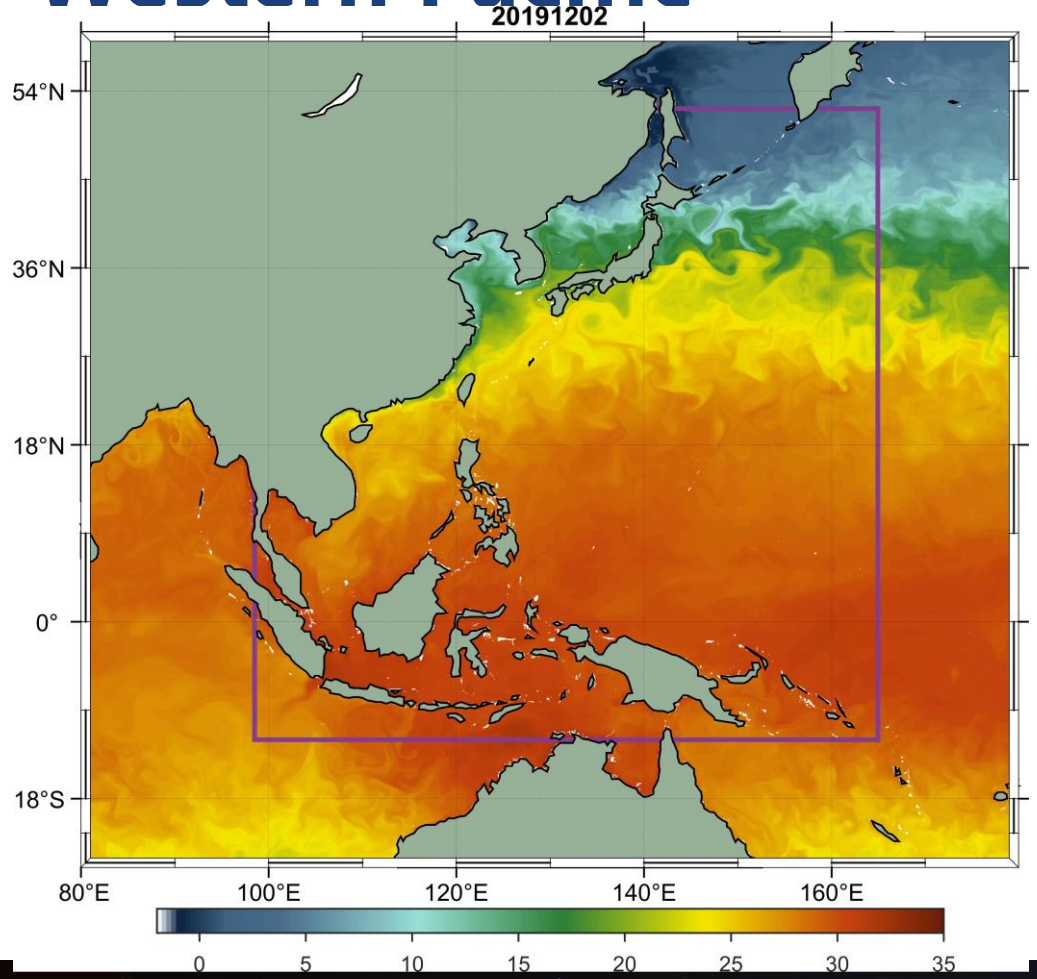
- Cubic Sphere
- 1/12° horizontal resolution
- MCM
- 4 A100 GPU
- No tide and ice till now

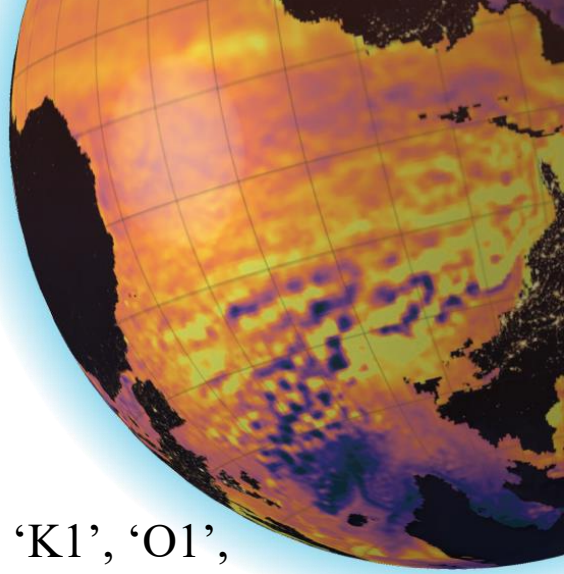


Root mean square error of 24-hour forecast

System	T(℃)	S(psu)	SST(℃)	SLA(m)
FOAM	0.61	0.08	0.49	0.06
PSY4	0.63	0.08	0.58	0.06
MaCOM	0.63	0.08	0.59	0.06
BLK	0.70	0.10	0.50	0.07
RTOFS	0.94	0.13	0.56	0.09
CMCC	0.80	0.10	0.56	0.06
GIOPS	0.57	0.08	0.61	0.07
NEMO （China）	0.79	0.12	0.53	0.07

Application of MaCOM in Western Pacific

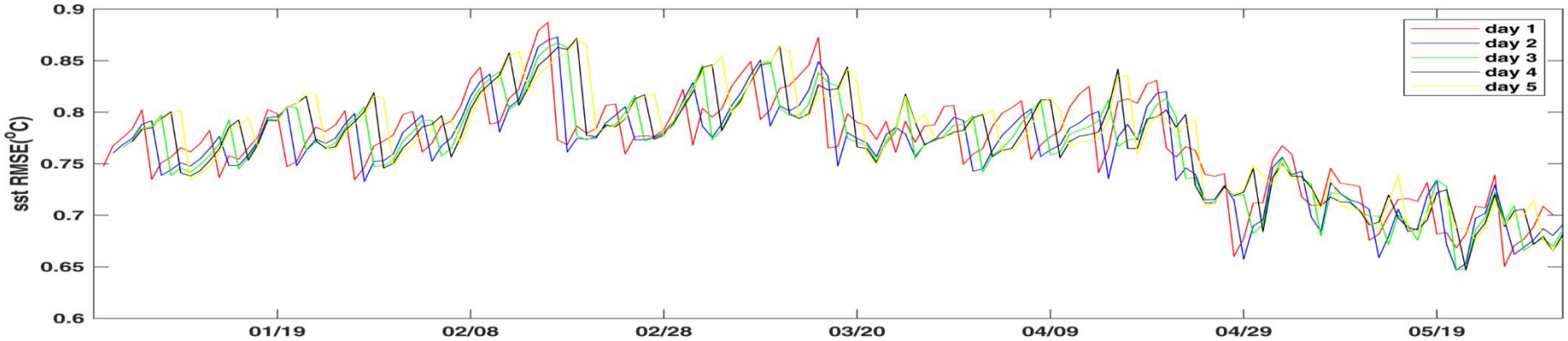


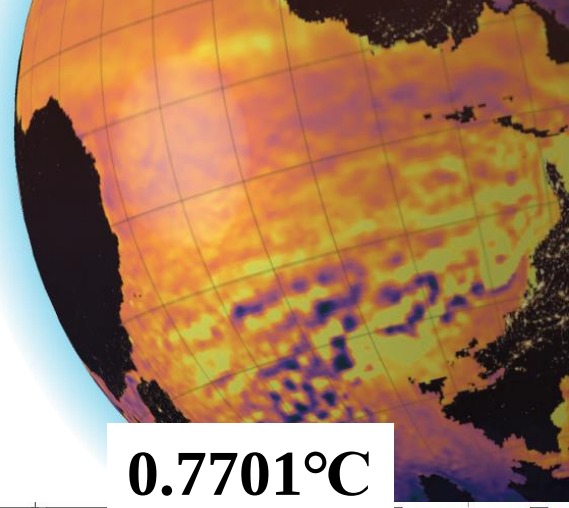


Regional application technology

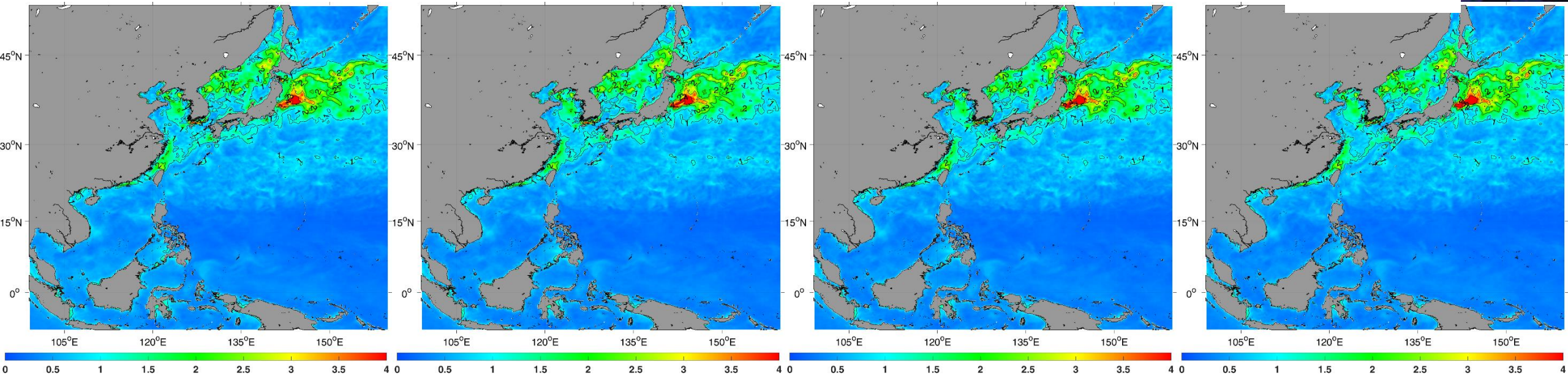
- Orlanski scheme
- Tidal Components ('M2', 'S2', 'N2', 'K1', 'O1', 'P1', 'Q1', 'K2', 'M4', 'MN4', '2N2', 'MS4')
- MCM
- up to 1/50° horizontal resolution
- latitude and longitude grid

Regional ocean circulation prediction - ROOM IX
Numerical simulation of the Northwest Pacific based on the MaCOM regional model
Z. Wang - NMEFC





0.7694℃ **0.7629℃** **0.7659℃** **0.7701℃**



Day 1 **Day 2** **RMSE of SST** **Day 3** **Day 4**

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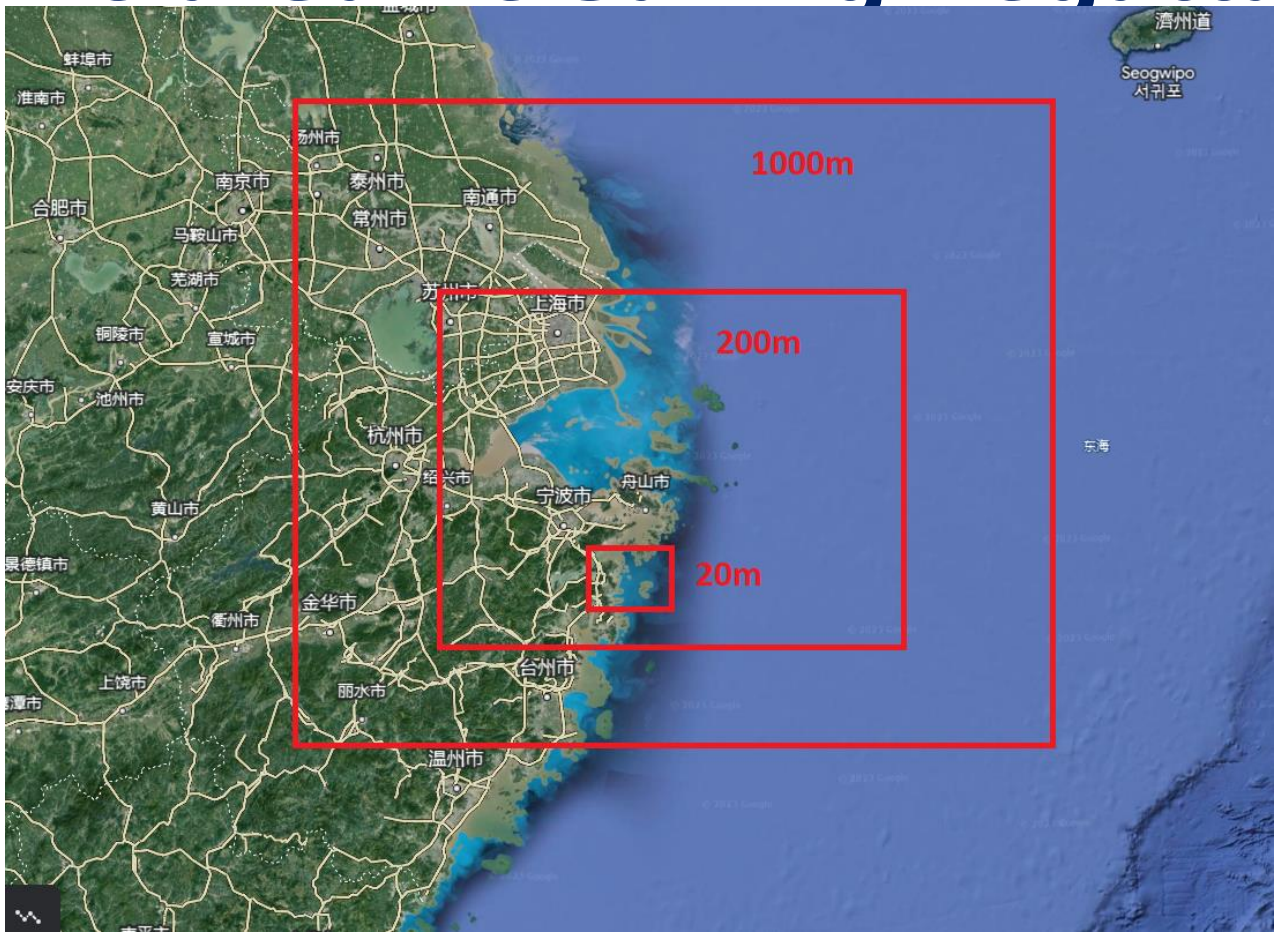
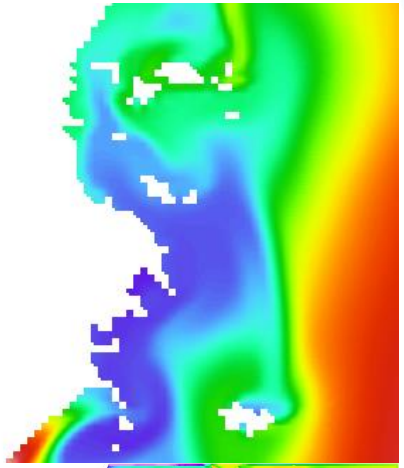
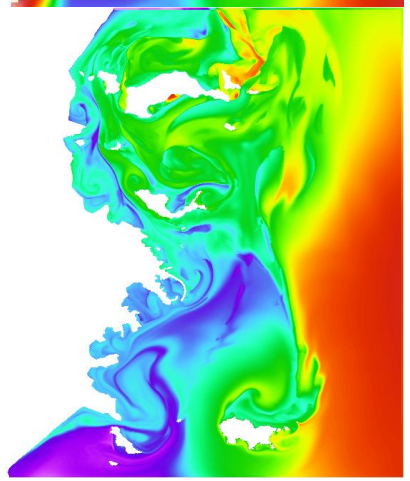
Application of MaCOM in Asia Game Sailing Regatta 2022

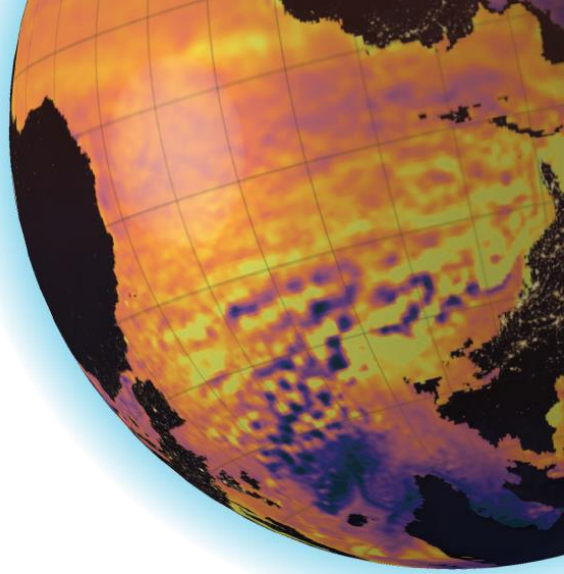


200m



20m





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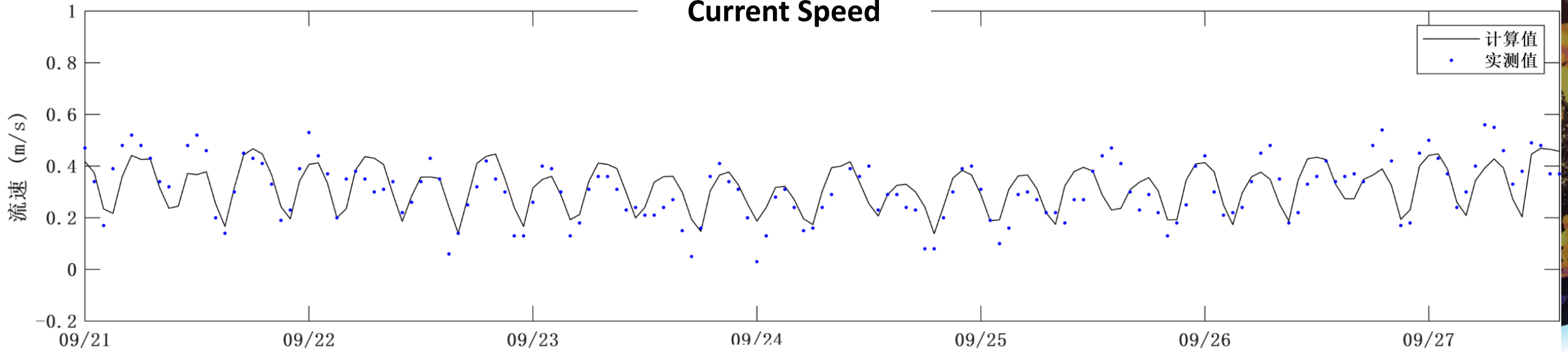
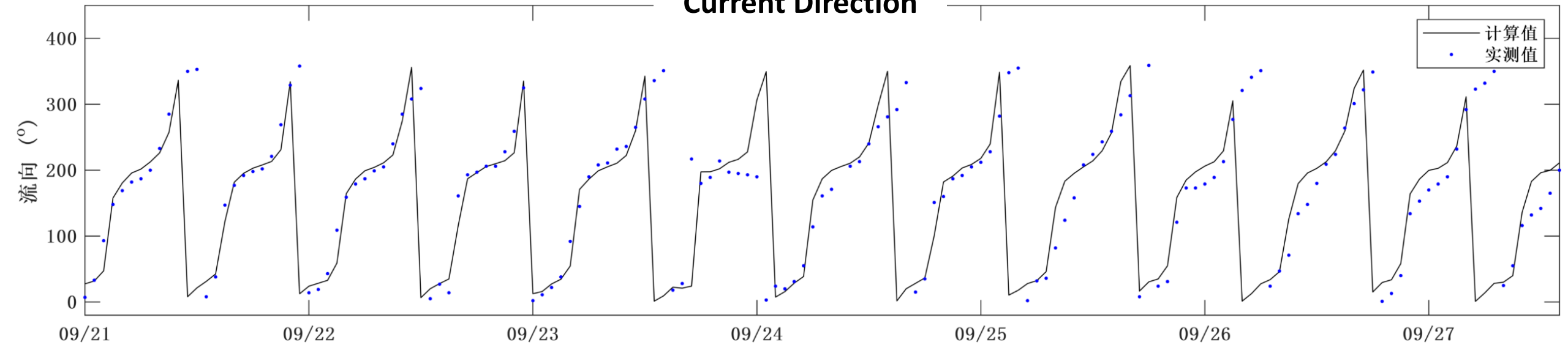
Current Speed



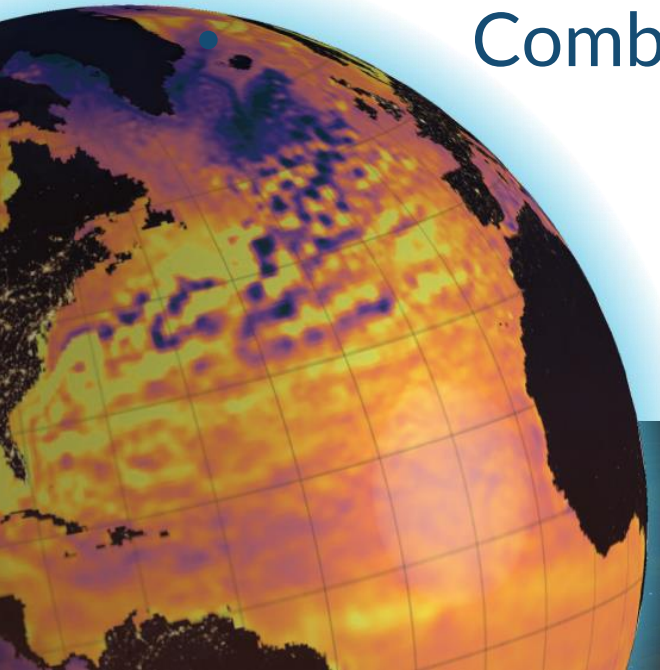
Current Direction

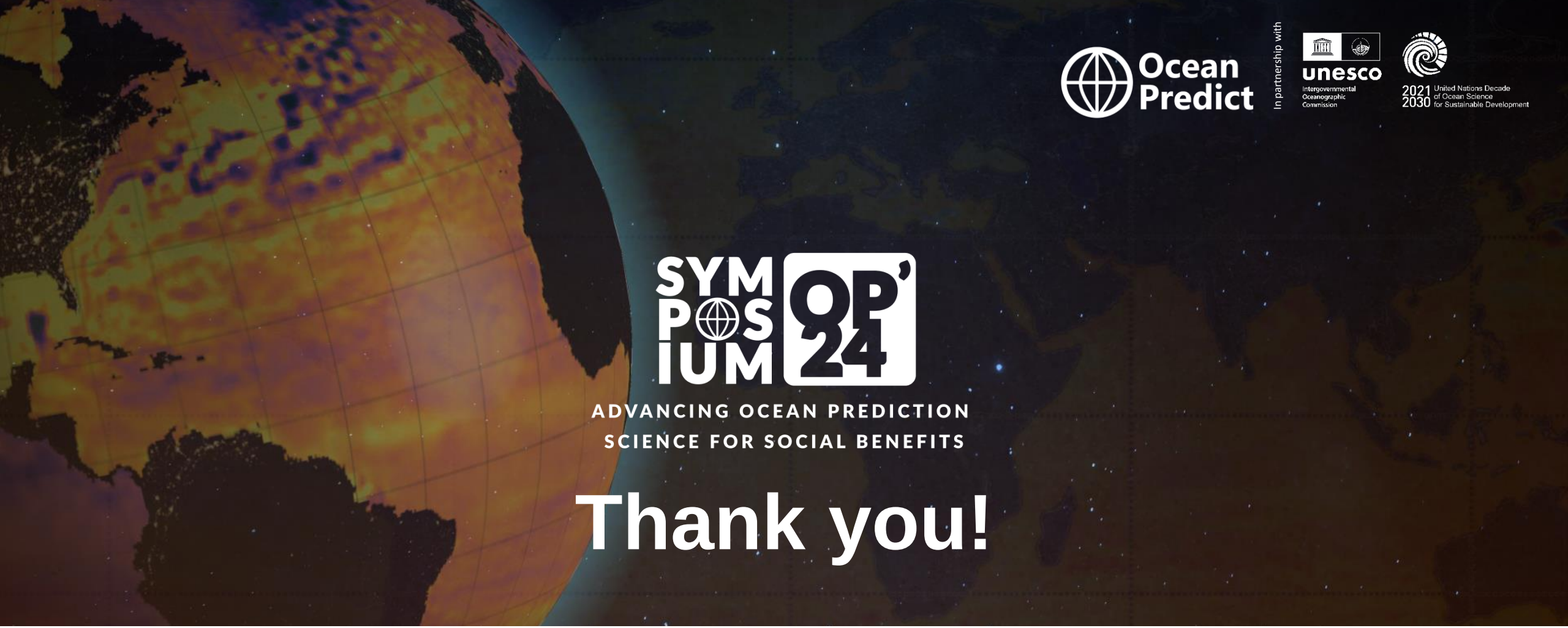


Conclusion and prospects

✓Fair performance in global applications

- Further assessment of model capabilities for coastal, regional, polar and climate prediction applications
- Coupling with ecological models and atmospheric models
- Combination with artificial intelligence technology





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ADVANCING OCEAN PREDICTION
SCIENCE FOR SOCIAL BENEFITS

Thank you!

European Commission

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EU4oceanobs
INTERNATIONAL OCEAN GOVERNANCE
EU COMPONENT TO GLOBAL OCEAN OBSERVATIONS

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